CLAIMS

What is claimed is:

1. A microprobe, comprising:

a housing having an aperture;

an ISFET attached to the housing, wherein the ISFET has a gate located proximate the aperture; and

a reference electrode attached to the housing proximate the aperture.

2. The microprobe of claim 1, wherein the housing and the ISFET are integrally formed in biocompatible material.

3. The microprobe of claim 1, wherein the housing and the reference electrode are integrally formed in biocompatible material.

4. The microprobe of claim 1, wherein the housing is a hermetically sealed encapsulant, and wherein at least a portion of the gate and at least a portion of the reference electrode are located within the aperture.

5. The microprobe of claim 1, further comprising a substrate attached to the housing, wherein the ISFET and the reference electrode are integrally formed on the substrate, wherein the ISFET and the reference electrode are monolithically integrated, and wherein the ISFET and the microelectrode are located on a portion of the substrate that includes the aperture.

6. The microprobe of claim 5, further comprising associated circuitry monolithically integrated with the ISFET and the reference electrode.

7. The microprobe of claim 6, wherein the associated circuitry comprises a temperature sensing diode.

8. The microprobe of claim 1, wherein the microprobe defines an exterior space that is exterior to the microprobe, and wherein at least a portion of the gate and at least a portion of the reference electrode are in fluid communication with the exterior space.

9. The microprobe of claim 1, further comprising an electrical power generator coupled to said ISFET selected from the group consisting of: battery, photovoltaic, chemical, radioisotope, and kinematic power sources.

10. The microprobe of claim 1, further comprising an antenna and a capacitor, wherein the capacitor is coupled to the ISFET, and the antenna is coupled to the capacitor, and wherein the capacitor is configured to store electromagnetic energy received by the antenna.

11. The microprobe of claim 1, further comprising a calibrant in contact with the gate of the ISFET and with the reference electrode.

12. A microsensor system, comprising:

a control module; and

at least one microprobe communicatively coupled to the control module, wherein each microprobe comprises:

a housing having an aperture;

an ISFET attached to the housing, wherein the ISFET has a gate located proximate the aperture; and

a reference electrode attached to the housing proximate the aperture.

13. A microsensor system, comprising:

an actuator; and

a microprobe proximate the actuator, wherein the microprobe comprises:

a housing having an aperture;

an ISFET attached to the housing, wherein the ISFET has a gate located proximate the aperture; and

a reference electrode attached to the housing proximate the aperture.

14. The microsensor system of claim 13, further comprising a cantilever arm attached to the actuator and the microprobe.

15. The microsensor system of claim 13, wherein the actuator is a piezoelectric actuator.

16. The microsensor system of claim 13, wherein the actuator is an electromagnetic actuator.

17. A microsensor array system, comprising:

a pad;

a plurality of actuators attached to the pad; and

a plurality of microprobes, wherein substantially each microprobe in the plurality of microprobes is attached to a respective actuator in the plurality of actuators.

18. The microsensor array system of claim 17, further comprising additional microprobes that are not attached to actuators in the plurality of actuators.

19. The microsensor array system of claim 17, wherein at least one microprobe comprises:

a housing having an aperture;

an ISFET attached to the housing, wherein the ISFET has a gate located proximate the aperture; and

a reference electrode attached to the housing proximate the aperture.

20. The microsensor array system of claim 17, further comprising a control module coupled to each microprobe.

21. A method for fabricating a microsensor probe for placement into tissue, the method comprising the following operations:

forming an ISFET in a monolithic semiconductor material, wherein the ISFET has a gate;

forming a reference electrode on said monolithic semiconductor material;

forming associated electronic circuitry in said monolithic semiconductor material;

operably coupling said reference electrode to said associated electronic circuitry;

operably coupling said ISFET to said associated electronic circuitry;

forming a hermetically sealed encapsulant around said monolithic semiconductor material, leaving an aperture in said encapsulant to permit fluid communication between a liquid in the tissue and at least a portion of the gate of the ISFET and at least a portion of the reference electrode, when the microsensor probe is placed in the tissue.

22. A method of monolithically fabricating an ISFET microprobe comprising:

providing a semiconductor wafer;

forming an n-well region in said semiconductor wafer;

forming a gate insulator on said n-well region;

patterning said gate insulator;

forming source and drain regions proximate said gate region;

forming associated circuitry from said semiconductor wafer;

forming a contact layer;

patterning said contact layer; and

forming a layer of photoresist.

23. The method of claim 22, further comprising:
forming a layer of silver on said photoresist;
reacting said silver on said photoresist to form a silver-silver chloride layer; and
developing said photoresist to form a silver-silver chloride reference electrode.

24. The method of claim 22, further comprising:
forming an AgCl reference electrode.

25. The method of claim 22, further comprising:
forming a Pt reference electrode.

26. The method of claim 22, further comprising:
dicing said semiconductor wafer to provide a plurality of die, wherein each die contains an ISFET sensor, a reference electrode, and associated circuitry;
forming interconnections;
forming an encapsulant housing; and
providing a microprobe delivery system.

27. The method of claim 22, wherein said semiconductor wafer is selected from the group consisting of: silicon-on-insulator and silicon-on-sapphire.